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THE PANAMA CANAL

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THE PANAMA CANAL

The completion of the Panama Canal is the realization of a commercial idea that has possessed nations and individuals, in turn, for the last four hundred years, and with its opening, the commercial geography of the western hemisphere, at least, is, in some respects, to be completely revolutionized. All nations of both hemispheres will feel an impetus given to trade and industry by the new and shorter routes, and steamship traffic—both freight and passenger—will be increased. America will open new lands to her eastern and western immigrants. Her splendid isolation, which has so influenced her whole history, her industrial development and her military policy, will be considerably lessened and her policies consequently modified.

Aside from the interest evoked by such wide commercial changes, the Canal demands one's attention "as the most difficult engineering project, both in design and construction, ever begun by any nation or individual." It has been a huge undertaking—one whose very bigness engages the interest of all people of all ages. It has been a very practical project and many big practical problems have been involved, problems which have centered themselves largely about the physical conditions of the area. And it is with a consciousness of the influence of the physical geography of the Panama area upon several of these problems, that the following material has been brought together in a bulletin for those interested in the great influence of the Canal upon the commerce of the world.

PHYSICAL CONDITIONS OF THE ISTHMUS

That a passage across the Isthmus of Panama has been the desire of all commercial nations, ever since the discovery that it was the narrowest barrier between the Atlantic and Pacific ocean, is clearly shown by the history of that country. This history is largely a series of attempts to put either a road or a canal from one side to the other, which attempts, however, can hardly be appreciated until the physical conditions of the region are known.

The Isthmus of Panama is a narrow S-shaped strip of land about fifty miles wide joining North and South America. It trends east and west in the latitude of about 9° N., across a north-south line drawn from the east coast of North America to the west coast of South America, and has until now formed an effective barrier between the two oceans of the western hemisphere, otherwise connected only through the frozen waters of the Arctic or the remote waters of the Antarctic.

The coast line is in general fairly regular with few good harbors. For this reason, the harbor at Colon on the Atlantic side and of Panama on the Pacific are much appreciated. The tides in these harbors, however, are quite different and it will be seen later that this difference has made the type of canal to be built quite a problem. At mean tide the water on the two coasts stands at somewhat the same level, but the differences between the high tides of the Atlantic and those of the Pacific and between the low tides on the two coasts are great. Half-tide, or mid-tide, at Colon varies only a little more than two inches, while high and low tides differ by eighteen or twenty inches,

high tide being nine inches above, and low tide being nine inches below, mid-tide. At Panama, half-tide may vary twenty inches, while high and low tides may vary by as much as twenty-two feet, high tide being nine or eleven feet above, and low tide being nine or eleven feet below, mid-tide. This difference in tides on the two coasts is probably due to the presence of outlying islands on the Atlantic side with practically none on the Pacific, and to the different shapes of harbors, the one at Colon being somewhat enclosed and the full sweep of the water also previously checked by islands, while at Panama the harbor is wide-mouthed and fully open to the sea.

A low backbone of hills near the Pacific shore runs throughout the Isthmus with an average elevation of 3,500 feet, though the highest hill in the Canal Zone, the narrow strip of land under the control of the United States, is only about 600 feet high. Along the Atlantic coast are swamps and marshes, rising into low hills, which are drained largely by the Chagres River and its tributaries. This irregular interior has steep-sided hills, narrow valleys, and small streams. On the Pacific side of the rocky ridge, the descent into the ocean is shorter and steeper than on the other side, and in the Canal Zone, is drained by a very short river called the Rio Grande. In the dry season, these streams are sluggish, the Chagres being about two hundred feet wide and only three or four feet deep, while in the rainy season, because of the steep slopes, thinly covered with soil, the narrow valleys, and heavy rainfall, that same stream becomes a raging torrent, rising sometimes forty feet in twenty-four hours, flooding miles of land, and for days sweeping everything before it. The two mentioned streams have been of much importance in the building of the Canal; first because their courses have largely determined the course of the Canal, and secondly because their great variation of discharge throughout the year has been a serious problem for the builders.

Because of the location of the Isthmus, the climate is purely tropical. This means little variation in temperature with a large number of days above 100° F. and few nights below 74°. The average for the year is 30° hotter than Chicago. The prevailing winds are the northeast trades, though as the thermal equator moves north in summer, southwest winds blow for some time off the Pacific Ocean, changing the heavy precipitation from the Atlantic to the Pacific slope. The rainfall is unevenly distributed throughout the year, and because of the slight variation of temperature the seasons are the wet and the dry. The rainy season is from May to December, while the thermal equator with the doldrums travels north across the Isthmus, turns, and crosses it again; the dry season is from December to May, while the thermal equator travels south and back again. The yearly rainfall at Colon is 128 inches, in the interior 92 inches, and at Panama 70 inches. This is, on the whole, three times that of Boston, two times that of New Orleans and twelve times that of El Paso. It comes in short rains of only a few hours, with fairly clear skies the rest of the time. Owing to the high temperature and nearness of water, the humidity is very high. This means that the air, in the rainy season especially, is damp and muggy, and exhaustive and oppressive to those unaccustomed to the Tropics.

In the matter of resources, Panama compares favorably with most of tropical America, having large forests of cabinet and dye-woods, uplands well suited to grazing and coffee growing, and fertile soil on the lower levels, which will produce all tropical crops. There are also valuable pearl beds in the Bay of Panama, and deposits of gold and coal not yet exploited. The principal exports now are tropical fruits, especially bananas and cocoanuts.

Because of the climate, though Panama closely approaches Indiana in size, its population is small, about 350,000. These are Americans, Europeans, some Chinese, and many of old Spanish blood; these form the better class and live mostly in towns. The natives are San Blas Indians, descended from the Indians of Balboa's time, negroes whose ancestors came as slaves in old Spanish days, and many dark-skinned people part Indian, part Spanish and part negro.

THE HISTORY OF THE ISTHMUS

In 1502 Columbus explored the harbor of Porto Bello and the Chagres River to the west of it. In his explorations, he went within ten miles of the Pacific Ocean, but he died in 1506 and the establishment of a Spanish colony was the only result of his explorations here. In 1513 Balboa sighted the Pacific from a high point of land on the Isthmus. On hearing later in 1517 of large quantities of gold on the western coast of South America, he forced the Indians to cut a roadway through the dense jungle, from the Gulf of Darien to the Bay of San Miguel, somewhat to the east of the present route. With this first road across the Isthmus, began the toll of human lives, which toll has been paid every time a road of any kind has been attempted. Two thousand Indians, nine out of every ten, are said to have perished in the task Balboa forced them to perform.

In 1524 Pizarro came from Spain and began the conquest of Peru, the richest and most highly developed part of the New World. As the consequence of the complete conquest of this rich land, immense quantities of gold and silver were sent to Spain, and to facilitate crossing the Isthmus a fine stone road was made by the Spaniards from the City of Panama to Porto Bello. It was fifty miles long and wide enough for two carts to travel abreast. No expense was spared in the building of this road and many traces of it, including parts of old bridges, can be seen in the midst of the jungle today. The cities at either end were strongly fortified and Panama became the richest and most famous city in America. In 1525 Cortez, the Spanish ruler of Mexico, found that from the Gulf of Mexico across to Tehuantepec Bay was only 120 miles, and that the passes through the mountains were only 900 feet above sea-level. So he built a highway at this point, known as the Tehuantepec Road, and from that day to this an extensive trade has been carried over it.

Because of the great wealth that was pouring into Spain across the Isthmus, especially by the Panama Road, and thence by ships to Europe, French, Dutch and English pirates began to infest the seas surrounding the West Indies, and to lie in wait for the gold-laden ships. Not only were the ships taken by these pirates, but between 1669 and 1671 Panama and Porto

Bello were both plundered and then completely destroyed. The fall of the City of Panama marked the beginning of the end of Spanish power in the New World. Though the Spaniards soon built a new town, the present City of Panama, five miles to the west of the old site, and spent, it is said, more than eleven million dollars to protect it, the trade, the wealth and the glory of the older days never returned. In 1811 Colombia declared herself independent of Spain, and the province of Panama joined her with the express condition that the province have the right of secession from the state at any time that she chose.

The idea of a canal across the Isthmus is as old as that of a wagon road. One of Balboa's men first proposed it, but no attention was paid to the suggestion until 1529, when Charles V of Spain had surveys made. At this time the Nicaragua route was first discovered. This route is by means of the San Juan River and Lake Nicaragua, lying between Costa Rica and Nicaragua, and requires little excavating to connect the lake with the Atlantic Ocean. It was carefully studied at the time, but the results of the investigations on the whole seemed to show the plan impracticable, as indeed it was with the tools of that day, and nothing was done. The idea was revived, however, with Phillip II, Charles's successor, and he laid the matter before the Dominican friars. They, in turn, wishing to obey the king's orders, but being wholly unable to report intelligently, searched their Bibles diligently for an answer, and at last quoted, "What God hath joined together, let no man put asunder." This was enough for King Phillip, the plan was abandoned and not revived for two hundred years. Early in the nineteenth century, in order to renew the country's prestige with Central and South America, the Spanish king decreed that a canal should be constructed across the Isthmus, but before any actual work was begun, most of her colonies had revolted and declared themselves independent.

England then made some effort, but with no result. In 1835 President Jackson of the United States sent someone to study the situation on the Isthmus. Some surveys were made and a franchise obtained from Colombia to build a railroad, but the panic of 1837 made the financing of such a project impossible for the United States. In 1838 a concession was given to a French company for the construction of a highway, railroad or canal. Surveys led to the canal being decided upon, but lack of capital made this attempt a failure. Even Scotland made some effort. All nations seemed to feel the need and value of such a connection but none were able to construct it.

By the acquisition of Oregon and California in the Mexican War of 1847, the need of a canal was brought before the United States again. There was no easy passage across the United States and the long route around Cape Horn had many disadvantages. For government service, for soldiers, and for the mails an easier route was necessary. The gold rush of 1848 sent crowds of excited men west; many of them went by caravans of horses and wagons from St. Louis, but thousands more went by ship to the mouth of the Chagres River, then across the Isthmus to the City of Panama, and again by ship to San Francisco. There were many shipwrecks in the rough Caribbean Sea and hundreds fell sick and died in the hot climate

of the Isthmus. In the single year of 1852, five hundred gold seekers died of cholera at Panama. Not only the government but people in general now demanded a safe passage from east to west.

Under these conditions it seemed profitable to a company of New York capitalists to build a railroad from what is now Colon to the City of Panama. They received exclusive right to build a railroad or canal, and decided upon the road. It proved to be one of the most disastrous attempts at road building in which American energy and bravery have ever been engaged, and by looking at their problems, it can be seen that they were the same as had been encountered by Balboa and his native workmen and they proved later to be, in a measure, the same as those met by the French and the United States in attempting a canal. Panama was a long way from railroad supplies, and materials were hard to get. The surveying was done by men waist-deep in water, pursued by insects, snakes, and alligators. There seemed to be no bottoms to the swamps into which load after load of dirt disappeared. The Chagres River, at time of flood rising ten feet over the tracks, swept away months of labor. No good laborers could be obtained. The natives worked one day and loafed the next, and the work they did was of little worth. A load of Chinamen was brought in, but at the end of two months all who hadn't died were sick. In desperation many of these drowned or hanged themselves, and the few remaining were shipped to Jamaica. Some Irish were tried with no better success. Then negroes were brought in from Jamaica and they did the larger part of the work. Disease was the great enemy; the steaming hot weather drained the men's energy until they were too weak to throw off the disease lurking in the filth of the city and the deadly air of the swamp. At last, in 1855, fourteen years before any railroad was laid across the United States, the forty-eight miles of Panama Road were completed at a cost of eight million dollars, five years of labor, and twenty-five hundred lives. Col. George Totten and James Baldwin are the men to whom the credit of this stupendous achievement is due. The time for crossing the Isthmus on this railroad was four hours and the cost twenty-five dollars; now the time necessary is two and one-half hours and the cost two dollars and forty cents. The gold rush put the railroad on a firm financial basis, the first forty-seven years bringing thirty-eight million dollars of clear profit, and this ended the prospects of a canal being built by the Panama Railroad Company, though many small promoters continued to investigate the routes.

The general opinion in the United States was, however, that the railroad was not wholly satisfactory, and in 1869 President Grant appointed the Inter-oceanic Canal Commission. By 1870 a treaty providing for the building of a canal by the United States if a satisfactory route could be found, had been signed. The rights of the railroad were respected and other routes investigated. At last the commission reported favorably on the Nicaragua route, but the United States delayed too long and the opportunity was lost. The French had already taken definite action.

FRENCH OCCUPATION

In 1878, in Paris, the Universal Inter-oceanic Canal Company was organized and incorporated by Count Ferdinand de Lesseps. He was a man over seventy years old but full of vigor and enthusiasm. He had recently succeeded in building the Suez Canal and was fired by the ambition to build a canal at Panama. Because of his great work at Suez, France was ringing with his praises and people were ready to put money into the new enterprise. Concession was obtained from the Colombian government to make a canal anywhere on the Isthmus, if satisfactory arrangements were made with the railroad company in case their territory was invaded. Surveys were made, and all but the Panama route reported impracticable. A sea-level canal from Limon Bay, on which Colon is located, to Panama Bay was agreed upon. It was to cost \$240,000,000 and take twelve years for building. The stock of the Panama Railroad was purchased for \$18,000,000.

According to the first plans the French canal was to be twenty-nine and one-half feet deep with a minimum bottom width of seventy-two feet; a tunnel was to be dug through the divide at its highest point; the difference in tides was to be reduced by sloping the bottom of the canal at the Pacific end; no plan was made for controlling the Chagres River. After some excavating had been done, and more problems had presented themselves, the tunnel was changed to an open cut, a tidal lock was to be built at the Pacific end, and a dam was to hold the Chagres back from the course of the canal.

The French equipment for this tremendous task was very inadequate, the work progressed very slowly and funds were used up fast. Waste and extravagance prevailed in all departments, apparently as the result of poor planning. Disease raged throughout the district in which work was being done. Hospitals were built at Panama and Colon, the one costing \$6,000,000 and the other \$1,400,000. Money was spent in large quantities to cure the sick, but no effort was made to prevent disease; the towns were still filthy and the water supply wretched. During the twenty-three years of work by the French 6,283 deaths occurred among their workmen.

De Lesseps was too old to manage so big a piece of work. Men whom he had trusted and put in charge of different parts of the work, proved dishonest and much theft occurred; some have said as much as one-third of all that was invested was wasted or stolen. Much money was misused before it ever reached America. As evidence of this, the Americans found, when they later took possession, three tons of French pens, for which they could find no better use than re-enforcement for concrete, and two thousand snow shovels—in a land where the natives wear practically nothing. Though the work progressed so poorly, the newspapers of France were bribed to give false and favorable reports. Farmers and day-laborers of France having put their faith in De Lesseps continued to put their money into the company until \$260,000,000 were used though the work was only two-fifths completed. At last, discovery of the true state of affairs was

made and the crash came. Many of the men involved committed suicide; many were imprisoned. De Lesseps, too old and weak to bear the shock, when given five years imprisonment, fell unconscious; his mind gave way and he died two months later in a mad house. A new company was formed and work continued rather half-heartedly with plans somewhat, changed, but practically no progress was made. Three words had told France's failure—disease, waste, theft.

ACQUISITION BY THE UNITED STATES

War with Spain in 1898, found the Oregon, the ablest battleship of the United States, in San Francisco Bay. When ordered to the Atlantic waters, it took two months at record speed to come by the Cape Horn route to the West Indies, a distance of 13,400 miles. If the ship had been able to use a passage through the Isthmus the distance would have been shortened to 4,600 miles. To meet the growing sentiment in favor of more satisfactory interoceanic communication, on March 3rd, 1899, the Congress of the United States passed an act authorizing the President to make full and complete investigation of the Isthmus of Panama with a view to the construction of a canal to connect the Atlantic and Pacific oceans.

THE ROUTE CHOSEN

There were five different routes that at different times had been contemplated by nations as possible for a canal, but the investigations of the United States centered about two—that at Nicaragua and that at Panama. The factors to be considered in solving the problem of which should be attempted were climate and floods, distance and ease of digging, storms and earthquakes. The canal at Nicaragua would be 120 miles longer than that at Panama but 117 of this would be through Lake Nicaragua. Then too, the San Juan River could be used in part, so that only seven miles of actual digging would have to be done. On the other hand, the floods of the San Juan River were as severe as those of the Chagres, and the frequent storms on Lake Nicaragua presented a difficulty. It was also thought that earthquakes were much more severe in Nicaragua than in Panama and might damage or even destroy the canal.

At Panama were two good harbors, a railroad from ocean to ocean, a canal partially completed and an immense amount of machinery of all sorts. This route was therefore the one first chosen by the United States and negotiations were set in motion to obtain from the French and from Colombia the privilege of building a canal here. For the advantages of this route, however, the French wanted \$109,000,000, and though this was less than one-half what they had put into it, it was considered too much by the United States which had set its price at \$40,000,000 and the final report to Congress was in favor of the Nicaragua route.

THE RIGHT OF THE UNITED STATES TO BUILD

The report to the United States Congress in favor of the Nicaragua route led the French to reconsider the offer of \$40,000,000 and to offer their

rights and property on the Isthmus for this sum. There was still Great Britain and Colombia to consult before the United States had full rights on the Isthmus. By the Clayton-Bulwer treaty of 1850, Great Britain held with the United States equal rights to build a canal across the Isthmus of Panama. A new treaty had to be negotiated therefore in order to give full rights to the United States. This new treaty took the form of what is known as the Hay-Pauncefote treaty, of 1901, by which Great Britain relinquished all rights on the Isthmus to the United States on the condition that "the canal be free and open to vessels of commerce and of war of all nations on terms of entire equality, so that there shall be no discrimination against any such nations, or its citizens or subjects, in respect to the conditions or charges of traffic or otherwise. . . . The canal shall never be blockaded nor shall any right of war be exercised, nor any act of hostility be committed within it. The United States, however, shall be at liberty to maintain such military police along the canal as may be necessary to protect it against lawlessness and disorder." In other words the United States was given the privilege of building and maintaining the canal, of undertaking this tremendous work and expense that all nations might reap the benefits equally. Most generous of Great Britain! Nevertheless some such treaty was necessary in order that the United States should get the right to build the canal, and though the treaty sounded as though the undertaking were purely philanthropic on the part of the United States, and though it has been criticized severely in view of later developments, the United States knew that big returns would come to her from it and the treaty was signed.

There was still the right from Colombia to be obtained. The United States offered her \$10,000,000 and an annual rental of \$250,000 for a strip of land along the Panama route. This strip was on her outskirts, in a province holding and at two different times in the past exercising her right to secede, an area subjected only by the force of arms to the position of province. Great benefits were to come from the building of the canal to both Panama and Colombia, but the latter country was without a normal and responsible government, there being nothing but an arbitrary dictatorship; no congress had been in session for several years, and with the hope of holding up the United States negotiations until the French franchise had run out, thus cheating that country out of any returns she might get for the work on which she had expended \$260,000,000 and also hoping to get for herself \$25,000,000 instead of \$10,000,000, Colombia refused to sign the treaty drawn up by her own and the United States representatives.

The plan of building the canal seemed so promising for Colombia that people could not help feeling that some corrupt influence had been at work contrary to the interests of Colombia and mankind. Panama seemed justified in exercising her old right of secession when such great benefits were denied her, and the United States felt justified in offering her protection in such a case. In consequence, the province of Panama seceded from the mother country and organized an independent republic, with which the United States negotiated a satisfactory treaty in February, 1904. The

action of the United States government in relation to Colombia and Panama of course caused very hostile feeling on the part of the former country, and has been severely criticised by many; but at the time, the United States administration felt that it was the only thing to do. Since then, however, it has seemed wise to pay to Colombia the sum of \$25,000,000 and give her perpetual rights equal to those of the United States so far as the use of the canal is concerned.

The agreement between the United States and the Province of Panama guaranteed the independence of the new republic and for \$10,000,000 secured for the United States absolute control of what is now called the Canal Zone. This Zone is a strip of land across the Isthmus forty-five miles from sea to sea and ten miles in width, five miles on each side of the proposed canal, its boundaries lying parallel to the mid-line of the canal. It has an area of 448 square miles. The United States also gained jurisdiction over all adjacent water for three miles from shore. To all intents and purposes, this agreement meant a perpetual lease from the Republic of Panama to the United States of all government rights and privileges in this territory. Yet it is not United States soil, for residents have no rights of United States citizenship, no voice in United States elections, while the citizens of the Republic of Panama who are in the Canal Zone are accustomed to go to Panama and Colon to vote. The cities of Panama and Colon, with certain adjacent water frontage, though within the five mile limit, are excluded from the Zone and are considered Panama territory, the United States having the right, however, to regulate the sanitary matters therein, and, if necessary to preserve order, may enter with an armed force and take possession.

In all, then, the United States paid \$50,000,000 for the original acquisitions on the Isthmus. Of this, the \$40,000,000 paid to the French included the excavation of 78,000,000 cubic yards of earth worth \$27,500,000, of which we are using one-half; the Panama railroad with 43,000 acres of land which originally belonged to the railroads, plus 33,000 acres otherwise acquired by the French, all valued at \$7,000,000; maps, drawings, and much technical data, worth \$2,000,000; and buildings and machinery of old style but fine quality and workmanship, valued at \$3,500,000. For the \$10,000,000 paid the Republic of Panama, the United States gained, besides the government rights already mentioned, all the public lands in the Zone, aggregating about 120,000 acres, together with the right to acquire by purchase or by exercise of the right of eminent domain any lands, buildings or water rights either necessary or convenient to the construction of the canal.

By the Spooner Act of 1903, Congress gave entire jurisdiction in regard to the construction of the canal into the hands of the President of the United States, the particular functions in regard thereto to be executed by a commission composed of seven members, presided over by one member as chairman. For convenience in administration, all canal operations were placed under the Secretary of War. Since 1903 there have been many changes in the Commission, but in 1907 the position of chairman and that of chief engineer were combined in one office, and Lieutenant-Colonel

George Goethals of the United States Army Engineering Corps appointed to the position. He held this important position until the completion of the canal, and although other men have had to do just as important work and almost as difficult work in preparing the Zone for occupation by white men, it is largely to Col. Goethals and the men under him that credit is due for the actual construction of the canal.

PREPARATION OF THE ZONE FOR ACTUAL WORK ON THE CANAL

On taking possession of the Zone, the United States took the responsibility for Ancon and Cristobal, suburbs of Panama and Colon respectively, twenty-five smaller towns, fifty thousand people of the Zone, plus the army of future imported laborers. The Commission, in sharing this responsibility with the United States, had then as its aim, not only the construction of the canal by means of efficient laborers, but the accomplishment of this task with as little cost in money, life, and culture as possible. This in turn meant the need of healthful conditions first of all; then safety of property, opportunities for education, recreation, and communication with the outside world. With these things a necessity, the first two and one-half years of occupation were taken up largely with just preparing for the actual work on the canal. With the knowledge of the 2,000 and 2,500 and 6,283 lives that were already charged to the enterprise, the Commission felt that their first efforts must be toward ridding the Isthmus of disease. Then there would be the work of recruiting and organizing a work force, of providing suitable homes, hotels, mess-kitchens and adequate food supply, of assembling various plants to do the work, of increasing the capacity of the railroad and of establishing a system of civil government.

THE FIGHT AGAINST DISEASE

The three most deadly diseases on the Isthmus were the malaria, yellow fever, and bubonic plague. The first two, when once a case appeared, were transmitted by the sting of the female mosquito, the malaria by the species *Anopheles*, the yellow fever by the *Stegomyia*. The plague was brought in by rats with fleas and other parasites, in ships from infested ports; these diseased rats from the ships carried it to other rats about the wharves, and these in turn went into the houses and carried the germs to the people.

The people of the Isthmus had come to look upon these diseases as inevitable; to them, malarial fever was a visitation of Divine Providence or a natural inconvenience. They were either ignorant of the causes of these different diseases, or if they knew, they were too lazy to remove them. No effort had ever been made to inspect incoming ships or to rid them of rats before allowing them to come into port; nor had any attempt been made to prevent the breeding of mosquitoes that carried the dreaded malaria and fever. Paved streets were unknown; water stood in small pools in the ruts of the muddy roads; there were no sewers or hydrants; all refuse from houses was thrown into the back yards and from there the water slowly ran out into the streets. The excessive rainfall kept the mass continually soaking wet, the hot sun beating down on clear days being

unable to dry out such places. With no city water supply the people depended upon tanks and barrels to catch the rain water, and these furnished excellent breeding places for the dangerous mosquitoes. Much of Colon was built on such low ground that there could be no drainage and all around were the swamps and jungle with poisonous air and more mosquitoes.

To clean up such conditions, there was needed a man with a thorough knowledge of tropical diseases and experience in fighting them; one with unlimited courage and patience. Furthermore he must be given all the money, men, and time necessary. Colonel William C. Gorgas of the Medical Corps of the United States Army was chosen for this great work. He had assisted in stamping out yellow fever in eight months in Havana, Cuba, where it had been epidemic for more than one hundred and forty years. He made a careful inspection of the Zone and said he would make it a fit place for white people to live in, and most of Europe laughed at his confidence.

The hospitals at Ancon and Colon, built by the French, were enlarged, and trained nurses and doctors put in charge; many smaller hospitals and camps with dispensaries were established along the line of the Zone, all carefully screened. These places were to take care of those already sick and to so isolate them as to remove at least one cause of further cases. Millions of loads of rubbish were scraped and shoveled out of the streets and yards of the town, carted away and burned. Plenty of drains and sewers were installed, streets were graded and paved so as to be kept dry, and adequate water supplies were established. To accomplish the latter, excellent reservoirs were built out in the hills beyond Colon and Panama, and the pure water piped into the cities in such quantities as to furnish fifty gallons daily to each inhabitant. Panama City is now considered the city in all Central America or northern half of South America, that is best paved and best supplied with sewers and pure water, while the whole Zone has an excellent system of roads and an abundant water supply. These improvements in the cities of Colon and Panama are to be paid for in the future by the taxes on the Panamanians.

Many of the residents of the Zone were satisfied with the old conditions and opposed to all this upheaval. This meant that they were not only failing to help Col. Gorgas and his men, but were actually hindering progress. Therefore Col. Gorgas selected a number of men, mostly intelligent natives, and sent them about day by day among the poorer classes to teach the value of keeping their houses, their streets, and themselves clean. Gradually the work of this corps of men began to show and the people co-operated completely with Col. Gorgas and his force. Furthermore there were thousands of ignorant laborers constantly pouring into the Zone, and these also had to be educated in ways of right living.

At the same time that this thorough cleaning was going on, a big fight against the transmitters of the diseases was being waged. All incoming ships were carefully inspected and the rats on them killed. Tons of rat poison were used around the wharves and in the towns, and a rat-brigade was formed to devote its whole time to the extermination of this pest. So

thorough was the work that the Zone is practically free from rats and with the rats has gone the plague. For the mosquitoes there were organized an *Anopheles* and a *Stegomyia* brigade; not that a member of one was averse to killing the mosquitoes assigned to the other, but each studied its variety in particular and tried especially to exterminate it. These mosquitoes breed and live only in water having impurities in it to furnish food for the larvae, and such as will allow these larvae to come to the surface for air. Kerosene and mosquito oil were poured over all stagnant pools, rain barrels were cleaned and screened, miles of ditches were dug and swamps drained, and great areas of jungle were cut down and burned. The houses were frequently fumigated and most carefully screened; strict quarantine was observed and all cases of yellow fever were isolated. This tremendous task, accomplished by Col. Gorgas and his corps of 1,200 men, cost on an average of \$2,000,000 a year—in all probably \$20,000,000 or five per cent of the entire cost of the canal; but the result is that a white man can work in the Canal Zone with as much safety as in most parts of the United States, and the death rate there at present is no higher than in New York City.

ESTABLISHMENT OF A WORK FORCE

To carry on the work of the canal, there were needed about five thousand skilled workmen, engineers, draftsmen, clerks, steam-shovel men, powder men, surveyors, and foremen, and about forty thousand laborers. These were obtained through large recruiting agencies in American and European cities. Americans proved by far the most efficient and most desirable in every way, but not nearly enough of them could be obtained. Good wages were offered, about once and a half as much as for similar work at home, to be paid in gold, and good living arrangements were offered, but workmen did not respond in large numbers. However, only Americans were employed as skilled workmen and these were on the whole of a very fine type. Many of them brought their families, and for these good schools and homes were established. These skilled workmen, paid in gold, were known as "gold men." The unskilled laborers were of various degrees of efficiency. There were among them Spanish, Italian, East Indian and negroes from Jamaica. They earned about a dollar a day, paid in silver, and were known as "silver men." The Jamaica negroes were the only ones to be obtained in large numbers and on the whole proved the least efficient. The work had many advantages for them—good wages, good homes, care when sick, and three hearty meals a day for thirty cents—better living arrangements than they had ever known before. They proved themselves, however, "studied" loafers, dull, stupid and slow. At first they objected to the good food because it made them feel too much like work. At the first drop of rain they were accustomed to fly for cover, refusing to work in it. There were only a few of the natives from the East Indies but they proved to be such satisfactory workmen that more were wanted than could be obtained. They are larger than the negroes and more energetic; they are peaceful, sober, and industrious, and were given the work of carrying the fifty-pound dynamite cases. They are proud of their

race and remained very much together, retaining many native customs. Among the latter was the wearing of the turban, which gave a very foreign look to any group in which they were working. The Spanish and Italian workmen were on the whole the most satisfactory of the unskilled laborers and about eight thousand of them were at work in the Zone. They are small and muscular, intelligent and reliable. They do about twice as much work in a day as the same number of negroes, were anxious for promotion, and worked with that in view.

The housing of the forty-five thousand workmen was no small problem for the Commission. Only a small proportion of the unskilled laborers brought families with them, but a fairly large per cent of the "gold men" brought theirs. The Commission received from the French a number of family quarters, and when it was necessary during the early days of canal construction to offer great inducements to get men to the Isthmus, the furnishing of family quarters within a reasonable time was made a condition under which the men were employed. In addition to the old ones, a considerable number of new quarters were built, and there were in the end accommodations for about fifteen hundred families of gold employes. No family quarters were built after 1908, and during the last year or so of work there were about four hundred applications for such quarters on file. These quarters were what one might expect to find among the same class of people in the United States, sanitary, comfortable and always carefully screened. They cost about twelve hundred dollars and up for each family. Bachelor quarters for "gold men" were furnished at a cost to the Commission of about two hundred and fifty dollars to five hundred dollars for each man. They contained pleasant sleeping rooms, libraries, rooms of recreation and exercise, and well equipped dining rooms, in which excellent meals were furnished. Much of the time there was a surplus of these quarters.

The unmarried "silver men," grouped in most cases according to nationalities, lived in barracks, which contained on the average twenty to thirty each. In the large sleeping apartments of these barracks were canvas bunks with iron frames, which were thoroughly washed and disinfected very often. A number of old French buildings were fitted up for quarters for the married laborers, about one thousand family quarters being provided for the West Indian, and about two hundred for the European, laborers. During the last few years there seemed to be a movement among the West Indian laborers to go into the "bush," where they put up a small shack, cultivated a small piece of land and felt thoroughly content and comfortable, housing and feeding themselves independently of the Commission.

Besides housing the workmen comfortably, the Commission attempted to give them good care in time of sickness. Besides the dispensaries and sick camps, there was a resident physician in each settlement and when necessary, hospital service and medical attention were furnished free to the employees, and to their families for a small charge. The Ancon hospital had a department for the insane added to it and a sanitarium for conva-

lescents was established on an island in Panama Bay. Employees had thirty days' sick leave with pay per annum, and thirty days' injury leave—far more consideration than the average workman in the United States.

Intimately connected with the housing and care of the employees, was the problem of feeding those who did not keep house, and of furnishing those who did with provisions and supplies. At every settlement where there were "gold men," a hotel was maintained for them where meals could be obtained for thirty cents each. In all, there were eighteen of these hotels on the Isthmus. The European laborers were fed in what were called "messes" where for forty cents a day they were given an ample supply of the food to which they were accustomed. Such of the West Indian laborers as were fed by the Commission ate at what were called "kitchens." They furnished their own mess kit, and after obtaining the amount of food to which they were entitled by their meal ticket, costing thirty cents for three meals, were at liberty to eat it where they chose, either in the "kitchen" or outside. There were forty-two of these "messes" and "kitchens" throughout the Zone. No alcohol was furnished in any hotel on the Isthmus but stated portions were furnished daily to men of the Latin races.

With forty-five thousand persons to be supplied and markets two thousand miles away, the problem of furnishing food and clothing was a big one. The Commissary Department became a big department store. It had a few large stores such as those at Cristobal, but many more small ones—twenty-two in all. As a source of supply for these stores, the Department operated a large ice-plant, a bakery, a big central laundry, and a cold storage plant. A few items of one daily output from these plants were ninety tons of ice, fourteen hundred loaves of bread, twenty-four hundred rolls, two hundred fifty gallons of ice cream, one thousand pounds of roasted coffee, and seventy-five hundred pieces of laundry. Prices for whatever was furnished from these places were little above cost. A supply train of twenty-one cars was sent from Cristobal every morning at four o'clock to carry provisions throughout the Zone. This train was composed of refrigerator cars containing ice, meats, and other perishable articles, and other cars containing other necessary supplies for the day. These were delivered at the stations along the line and distributed to the homes of the employees.

EQUIPMENT

The mere collecting of machinery and materials sufficient for such a task and at such a distance from the source of supply was no small problem and one that had to be pretty well solved before any real work on the canal could be started. The French had left an immense amount of machinery scattered along the line of their excavations, locomotives, dredges, scows, tugs, cars, and track, but it had not been used since 1899 and was very much rusted and out of date. Some of it, however, was such as to be of use to the Americans in the first two and one-half years of occupation and what could not be used was sold as junk, bringing \$500,000. Finally, however, practically an entire new outfit of tools and machinery was nec-

essary. Locomotives and dump cars, dredges and steam-shovels, barges and rock-crushers, track shifters, pile drivers, cranes and steamboats, together with a vast amount of hand tools were purchased far in advance of the beginning of actual work on the canal and shipped to the Isthmus. The largest cement-mixing-and-handling plant ever built, was established; compressed air plants for furnishing power for drills were erected and great repair shops begun. To facilitate the handling of the incoming machinery and supplies of coal and lumber, docks were built, miles of double track laid with heavier rails, and larger yards and cars than those used by the French supplied. The repair shop established at Empire is typical of the thoroughness with which the men in charge endeavored to forestall delay or inefficiency from any cause. It was close to the line of the canal and the railroad tracks were so arranged that even the largest pieces of machinery could be brought directly to the shop. The equipment was in every way modern and equal to the best railroad repair shops in the United States. With it there were also a foundry and a lumber mill, a great store house with ten thousand different articles used in the machines throughout the Zone, with one thousand workmen employed. It is said that any piece of machinery in the Zone could be repaired or rebuilt at Empire.

Besides all this preparation in a material way, laws for the maintenance of peace and safety had to be formed. Civil government was established with all the necessary adjuncts of courts and police force. Fire companies were organized, custom and revenue service, and seventeen post offices established. Then, and not until then, did the Commission feel ready for actual excavation to begin.

THE TYPE AND PLAN OF CANAL

While the great work of preparing the Zone for American occupation was going on, the problem of the best type of canal to be built was being investigated. This depended upon the character of the country through which the canal was to go. To study this and weigh the values in this country of both the sea-level and the lock canal, President Roosevelt appointed a Board of Consulting Engineers, thirteen in number, eight Americans and five Europeans.

By the sea-level canal is meant merely a great open ditch dug at the same level between two bodies of water, allowing the water of one ocean, in this case, to meet the water of the other at sea-level. This type has some strong advantages over the lock canal. It is simple in construction, needs no machinery for operating, and causes no particular delay to ships passing through it. The Cronstadt Canal of Russia, the Corinth and the Suez canals are of this type, but they are not in countries of the character of Panama. Here there were many disadvantages for such a type. It meant an immense amount of excavating, if it were made deep enough for modern ocean steamships and wide enough for two to pass, which amount would take such a long time and be such an expense that it seemed unwise for the United States to undertake it at this time. Furthermore, in some places, the resulting height of walls would demand further excavating to

reduce the slopes or the heavy rains and streams of the region would cause disastrous results. Even if the slopes were so reduced as to prevent sliding and caving, it is very likely that the amount of wash in time of flood would cause an inconvenient amount of silting in the channel. The greatest disadvantage in this type of canal, however, lay in the different heights of water in the two oceans. At high tide the Pacific ocean, standing about ten feet above that of the Atlantic, and at low tide about ten feet below, would cause a fall of about ten feet in fifty miles, which would mean enough current to mean considerable wash. Furthermore, if on the Pacific side the tide runs ten feet above mid-tide in the open harbor of Panama, it would pile up still more as it swept through the canal and would be very apt to cause a troubled condition of the water. Under the existing physical conditions at Panama and with the time and money at the disposal of the government the sea-level type seemed impossible.

Six of the nine large ship canals of the world are of the lock type, the Erie and the "Soo" canals being examples in the United States. In this type all parts of the canal need not stand at the same level. A portion, called a lock, is enclosed by strong walls and shut off from the remainder by gates. By means of machinery, these gates can be opened and shut at will, the water in the lock can be raised and lowered at will, and a ship having entered from a lower portion of the canal can be raised to the level of the higher part; or entering from the higher part can be lowered to the level of the remaining portion. The greatest advantage of this type is that it does away with the difficulty arising from the different heights of the two bodies of water. Furthermore, it meant less excavating and therefore less time and money, and though it meant a delay for ships passing through the canal and an expense in operating the locks, these disadvantages were outweighed by its advantages and the Board of Engineers and the President finally voted in favor of this type. In June 1906, the construction of the lock canal at Panama was authorized by Congress and plans were begun at once.

As the completed canal stands now, it is an eighty-five foot lock canal. The water is held at this level by a dam across the Chagres River at Gatun on the Atlantic side and by one across the Rio Grande at Miraflores on the Pacific side. By these dams lakes have been formed behind them, and these lakes made to flow together through the deep Culebra Cut made in the ridge of rocky hills in which the two streams rise on opposite sides. Culebra is the Spanish word for snake, the natural pass between Gold Hill and Contractor Hill being very winding. In excavating, however, the cut has been straightened. Approaching the canal from the Atlantic Ocean there is first a sea-level entrance, seven miles long, with a channel five hundred feet wide and forty-one feet deep. This entrance reaches the Gatun locks, just east of the dam at Gatun. The locks are a flight of three in duplicate, one set of which raises an entering ship eighty-five feet to the level of the inland canal, the other lowering out-bound boats to the sea level. The dam was put across the old channel of the Chagres River, a hilly island in the middle being used as a part of it. In this hill was placed a concrete spillway with

steel gates to regulate the flow of water from the lake. Gatun Lake extends from Gatun Locks and Dam over one hundred sixty-four square miles to the hills on the Pacific side of the Isthmus. Through this lake, the channel of the canal is twenty-three miles long, five hundred to a thousand feet wide and forty-five to eighty-five feet deep. At the west end of the lake, Culebra Cut is nine miles long, three hundred to five hundred feet wide and forty-five feet deep. At the Pacific end of the cut is a pair of locks at Pedro Miguel, which lowers a Pacific-bound ship thirty feet to the level of Miraflores Lake, a small lake only four square miles in area, made by the dam across the Rio Grande at Miraflores. At each side of the locks at Pedro Miguel is a small dam, reaching from the locks to the neighboring hills and holding the water in the cut at an eighty-five foot level. Miraflores Lake is fifty-five feet above sea level, and the course through it is only two miles long. At the west end of it, is a flight of two locks in duplicate, which lowers the outward bound boat to the Pacific level, where there is a sea level entrance from the ocean eight miles long, five hundred feet wide and forty-five feet deep. The total length of the canal is about fifty miles and the passage through it occupies about twelve hours.

The advantages in this plan for the canal are—(1) the lake made by the Chagres River being dammed is so large that the greatest floods of that stream cannot raise it more than one or two feet: (2) little excavation in comparison to that demanded by other plans has been necessary and therefore time and expense have been saved : (3) the silt carried down by the Chagres and its tributaries is now dropped along the edge of the lake, where it can have no effect on the channel for the ships.

Constructions for the canal have not been confined entirely to the land. Storms are troublesome on the Atlantic coast since the winds for a large part of the year are from the northeast and drive directly into the mouth of Limon Bay, through which the ships enter the canal. A stone breakwater has therefore been built out from Torro Point on the west side of the bay, and extended for two miles in a northeast direction. From the east side of the bay a breakwater three-fourths of a mile long has been built in a northwest direction. On the Pacific side, a shore current from the east carries large quantities of sand into Panama Bay, keeping the channel very shallow. To make a good entrance here, much dredging has been done and a breakwater built from the mainland to Naos Island, four miles out on the east of the bay. Both breakwaters are well lighted at night.

The Panama Railroad has been submerged by Gatun Lake, and has therefore had to be almost entirely rebuilt on higher ground considerably to the east of its old course. There has been a question in the minds of the Commission whether this railroad would have sufficient business after the canal is completed to warrant the expense of rebuilding. Whatever business it has will doubtless be confined to Colon, Panama, and intermediate points, and very likely it will finally be operated by electricity.

CONSTRUCTION OF CANAL

The accomplishment of such a tremendous amount of work as was

before the chief engineer called for the most careful organization. When Col. Goethals took charge of the work he decided it could be most economically done if put under three different engineers, working in three different sections, the Atlantic, the Central, and the Pacific, so chosen because of the different kinds of problems arising in these sections. In each section there were three different classes of work, the wet excavation carried on by dredges and covering about twelve per cent of the entire labor necessary; the dry excavation done by steam shovels or picks and shovels and including about forty-nine per cent of the entire work; and the construction of dams, spillways, and locks. Each of these different classes of work was put under the charge of a separate man.

WET EXCAVATION

The problem everywhere in the work was to use the machinery and method which would accomplish the work with the least expenditure in time and money. Wet excavation—i. e., digging channels by dredges—was possible in the harbors at either end of the canal and in the low swampy places along shores and streams. As this method proved to be cheaper than any other way of digging, the engineers used the dredge wherever possible and, in all, about sixteen miles of channel were cut by them.

Twelve or fourteen excellent dredges and several others of less value were kept at work both day and night. Of these the American sea-going suction dredges were by far the most powerful. They were operated by centrifugal pumps, by which the silt from the bottom of the harbor was sucked up and emptied onto barges brought alongside the dredge. When full, the barges steamed away to the dumping ground and other barges came up. These dredges had the largest output of any and two of them will be kept for future use. A few dredges were equipped with big pipes for carrying away the silt, and proved most effective around the dams. Here, the pipes were so arranged that the material dredged up from the bottom was immediately poured between rock piles to furnish a filling for them. It was also possible to use seven old ladder dredges, three dipper dredges and several clam-shell dredges left by the French. Each of these ladder dredges had a series of large buckets on a sort of endless chain. A powerful arm carried the buckets to the bottom and when these were set in motion each one cut away, brought up, and dumped a load of earth. The dipper dredges had only a long arm with a dipper or scoop on the end, which dipped down to the bottom and scooped up material. When such a dredge was used for rock material, it was accompanied by a rock-breaker. This consisted of a large ram, mounted on a barge. The ram weighed ten to nineteen tons, and was on the end of a rod thirty to fifty feet long. When this was raised four to ten feet above the surface of the water and forced down, it broke the rock to a depth of about three feet. In some places where there was very hard soil or rock, a dredge was of no use until under-water dynamiting had been done.

DRY EXCAVATION

The dry excavation was done almost exclusively by steam shovels, fifty or sixty working on the main channel alone. Each shovel that worked on anything but soft earth was preceded by a battery of four to twelve drills, worked by compressed air from the power plant, drilling holes for the blasting. This again was planned to accomplish the most in the least time. Many holes were drilled for each explosion, some only three or four feet deep, others ten or twenty times that. These holes were skillfully arranged by the powder men so as to get the greatest possible effect. Sometimes small charges were put in and set off before the final charge, in order to enlarge the holes at the bottom and allow a larger final charge. The final charge of one set of holes often used a number of tons of dynamite and a million pounds was an average amount for one month's use. When all the holes were at last charged, a small cap with an electric wire attached, was placed over each hole, the drills were moved away, the men retired, and a single button, attached by the wires to the caps, was pressed. This set off the complete charge. This method was sometimes the cause of accident, one charge perhaps failing to go off until disturbed later by the shovels.

The steam shovels proved as effective in dry excavation as the dredges in the wet. The dipper of one large steam shovel could take at one load nearly five cubic yards of material, weighing seven or eight tons. Three or four of these loads filled a car. These shovels worked so fast that the problem was to keep enough cars ready to take the load. Considerable rivalry was developed among the operators to see which could hold the best record for number of cars loaded, the record at one time being thirty-five hundred cubic yards or seven hundred tons loaded in an eight-hour day.

In order to economize in time, labor, and expense, the aim everywhere in the excavating was to use the material excavated in some other part of the work. All that was suitable was carried to Gatun Dam; other qualities were used for reclaiming lowlands and building embankments for the Panama Railroad. The method of unloading the flat cars was one to save much labor. The space between each two cars was covered by a small steel bridge. A five-ton steel plow stood diagonally across the end of the last car, connected with the engine by a strong one and one-half inch steel cable from its upper edge and fastened to the sides of the car in such a manner as to slide freely from one end of the car to the other, when the cable was wound up. When a loaded train reached the dumping place, this plow was drawn by means of the cable from the rear of the train to the head, the cable being wound on a drum near the engine. A sixty-ton pull was thus exerted and the plow scraped the cars clean as it traveled, piling the dirt alongside the train. Two or three men could thus do the work of thirty or forty.

The largest number of laborers employed for any one piece of work was employed moving and ballasting track. Culebra Cut alone had fifty-

one miles, one mile being shifted every day. Swamp lands that were being filled up as dumps, were other busy places for these laborers. When the material which was so skillfully scraped from the cars was to be used as a roadbed, it had first to be spread out. For this, a spreader, another labor-saving machine, was used. This consisted of little more than a locomotive with a big scraper, similar to a road scraper, out at one end. As the locomotive approached the ridge of material to be smoothed off, the scraper was lowered, and being held firmly in place, scraped all the loose material out into a level stretch, again one or two men doing the work of many. This ground was then ready, in this place of only temporary tracks, to have the track on which the cars and spreader had run, shifted on to it, so that the next loads could be dumped a little farther out. A track-shifter consisted of a locomotive, from one end of which extended a strong arm or crane; from this arm was suspended a strong chain holding two immense hooks. Two laborers made these hooks grip the rails of the track, the operator of the locomotive then lifted the crane bringing rails and ties still intact, swung it out to the side and laid the track down on its new bed. This shifter could throw the track nine feet to the side without the rails breaking, but the usual throw was less than half this.

It was found necessary to keep the water out of Culebra Cut while the excavating was going on. For this purpose, a dike was left in at Gamboa, at the northeast end of the Cut and diversion channels made on either side of the hills to take care of any water that had to drain parallel with the Cut. The dike at Gamboa was the last place in which any large amount of blasting had to be done and for which President Wilson set off the charge.

SLIDES

At various points along the banks of Culebra Cut, the excessive rainfall and the character and slope of the material resulted in the movement of soft material on layers of slippery clay. These moving masses were called "slides." There were more than twenty-five in all, the twelve largest covering from one to forty-seven acres each. The most troublesome was the Cucaracha, which had been in constant motion, slow and irresistible like a glacier, ever since the occupation by the French in 1884. This slide kept a constant barrier across Culebra Cut. The first twenty-five slides had a total area of two hundred twenty acres and added twenty-five million cubic yards of excavation to the work, enough to make Gatun Dam.

Sometimes the slides took the form of big blocks settling into the Cut; at other times the pressure on the sides was so great as to cause an upward pressure in the middle of the excavating. Attempts were made to bolster up the sides with cement, cement guns being used to blow liquid cement into the sides of the rock. This proved unsuccessful, however, and Col. Goethals' only prescription was unremitting excavating. This excavating was done largely at the tops of the slippery place, so as to lighten the load, and the banks thus became terraced. Besides meaning more excavating, the slides often stopped drainage, overturned shovels, buried tracks and small tools,

and in some cases meant considerable loss. Yet while annoying and, in themselves, of some importance, when compared with the canal operations as a whole, they were insignificant, and affected the total amount and cost of the work by less than one per cent. Since it is only the shallow top layer of soft earth and disintegrated rock that has been causing the trouble undoubtedly before all small details of the canal are completed, the banks will be covered with enough tropical vegetation to hold them permanently in place. In any places where there seems to be danger below or near the level of the water in the canal, a concrete lining has been placed.

CONCRETE CONSTRUCTION—THE DAMS AND SPILLWAYS

Besides the excavating that has been necessary to make a suitable channel for the ships, there has been necessary the powerful dams to hold the waters of the Chagres and Rio Grande Rivers at eighty-five and fifty-five feet levels respectively, and the big locks for the raising and lowering of the ships to and from these lakes. To some, this part of the work has seemed the most wonderful. The great importance attached to Gatun Dam, however, was due to its great size rather than the complicated plan or difficult work in building it, many dams having been built in the United States to receive much greater pressure and greater heads of water, without being given one-hundredth the amount of attention. Gatun Dam is seventy-five hundred feet long, but has the pressure of the whole eighty-five feet of water against only about five hundred feet of it. The natural surface on which it is built rises rather abruptly on the two sides of the old stream bed, so that this surface itself takes much of the pressure. For only about one-half its length will the head of water on the Dam be over fifty feet. In the building, two long piles of rock, largely from the excavation in Culebra Cut, were placed twelve hundred feet apart, parallel with the central core of the dam, having a height on the upstream side of sixty feet and the downstream side of fifty feet. These rock "toes," as the piles are called, confine the body of the dam, which is mainly of impervious material, sand and clay properly mixed, pumped in by dredges. Outside the "toes" are waste piles made from the spoil of neighboring excavation. These waste piles slope gradually and extend indefinitely so far as material has been available. The total thickness of the dam at the base between the outer edges of the waste piles is fully two thousand feet; the thickness at the water-level is three hundred ninety-eight feet. The top of the dam is thirty feet above water-level and has a width of one hundred feet. The spillway for regulating the level of the lake was placed in the small, rock hill, that stood in the middle of the stream and which now forms part of the dam. This spillway is a great crescent-shaped, concrete dam eight hundred eight feet long with its crest sixteen feet below the normal level of the lake. At regular intervals along the top of it are thirteen concrete piers, between which are tight-fitting, steel gates that can be raised and lowered by electrical power to regulate the flow of water from the lake.

The lake, extending through Culebra Cut to Pedro Miguel, is held at the latter place, between the locks and the hills to the west, by an earth

dam fourteen hundred feet long with its crest one hundred five feet above mean tide; between the locks and the hills to the east is a concrete-core wall. The dams at Miraflores, which hold back the lake of that name, lie one on either side of the locks, connecting their walls with the high ground on either side. The one to the westward is of earth about twenty-seven hundred feet long, and having its crest fifteen feet above the water in Miraflores Lake. The dam to the east is of concrete, about five hundred feet long, and forms a spillway to Miraflores Lake, with crest-gates similar to those of Gatun Dam.

THE LOCKS

The controlling principles in building the locks were (1) to make them safe and (2) to make them adequate in size and arrangement. Those at Gatun consist of six immense concrete chambers, each one hundred ten feet wide, one thousand feet long and eighty-one feet deep, separated by double steel gates. Special effort was made to secure a good foundation, the concrete being thoroughly re-enforced, largely with old steel rails from the French railroad. The side walls are forty-four to fifty feet wide at the surface of the floor, vertical on the inside face and narrowing by steps on the outside face from a point about twenty-five feet above the floor until they are eight feet wide at the top. The middle wall is sixty feet wide and vertical on both faces. The gates between the chambers are steel structures sixty-five feet long, from forty-seven to eighty-two feet wide, and seven feet thick, being wide enough to serve as bridges when closed. They weigh from three hundred to six hundred tons each, but air-tight chambers inside make them buoyant. They are made with all the nicety of a watch, and in one minute and forty-seven seconds can make the three sets of chambers perfectly water-tight.

Through the three walls near the floor level, run immense culverts, two hundred fifty-four square feet in area of cross-section, which is about the area of the Hudson River tunnels of the Pennsylvania Railroad. These are made in the concrete by steel cylinders being laid inside the frames for the walls and the concrete being poured around them. The cylinders are collapsible and can be drawn out by a locomotive after the concrete has set. From each of these large culverts, several smaller culverts, thirty-three to forty-four square feet in area, extend under the floor of the lock and communicate with the lock chamber through holes in the floor. The large culvert in the middle wall feeds in both directions through laterals, thus permitting the passage of water from one twin lock to another, effecting a saving of water. Valves are placed in the large culverts near the gates between the chambers. To fill a lock the valves at the upper end of the chamber are opened and the lower valves closed. The water flows from the upper pool through the large culverts into the smaller laterals and thence through the holes in the floor into the lock chamber. The average time for filling a lock is about fifteen minutes, without opening the valves so suddenly as to create disturbing currents in the locks or approaches. A ship approaching the locks at Gatun from the Atlantic side

comes to rest outside the locks. The gates to the first chamber open, the level of the water in the lock and the sea-level entrance becoming the same. The ship is towed into the lock and the gates closed behind it; by the manipulation of the valves in the culverts, water flows into the chamber until the level here becomes the same as in the second chamber, when the gates between the two locks are opened. The ship passes into the second chamber, the gates behind it close, and the same operation is repeated.

SAFETY DEVICES FOR THE LOCKS

Several devices were used for safety around the locks. Double gates were established to separate a high level from the next below, the two gates being operated simultaneously. In case a ship rams or crushes one gate, the next prevents a rush of water. A chain is stretched across each lock near the surface of the water, in front of an approaching ship and near the gates, and can be so operated as to arrest a ten thousand ton vessel moving at a speed of six miles an hour. When not in use it will lie in a groove in the lock floor. In case the double gates be carried away or repairs become necessary in the bottom of the lock, there are emergency dams that can be used. Each one of these consists of a swing draw bridge that can be thrown across the lock and from which wicket girders can be lowered one at a time, the upper ends being supported by the bridge and the lower ends by a sill in the bottom of the lock. Steel plates can be let down on the upper side of these girders, crosswise of the lock, their ends fitting closely into the walls of the lock, so that the pressure of the water against them holds them close to the girders and makes a water-tight barrier. By this means, the flow of water through the lock can be checked in an hour. In addition, a further safeguard was adopted to minimize the chances of accident. Practically all recorded accidents to locks in recent years have occurred through some mistake in signals between the pilot house and the engine room while the vessel has been passing through the locks under its own steam. To obviate this source of danger, there are provided on the walls of the locks, electric locomotives, which under proper control tow the vessels through the locks, the vessels not being allowed to move their propellers meanwhile. There are four locomotives to each ship, one on each side forward to tow, and one on each side astern to keep the ship in position in the lock. A hydro-electric plant was established to generate power by water turbines from the head created by Gatun Lake. This power also lights the canal throughout its course, besides operating the gates, valves, and locomotives. Small craft go through the locks under their own power. It seems as if these precautions should make passage through the locks safe.

The locks at Pedro Miguel and Miraflores are practically the same as those at Gatun. The time occupied in locking through all of them is about three hours out of the twelve hours necessary for passing through the entire canal.

METHODS OF HANDLING CONCRETE AT THE LOCKS

The principle of labor-saving was as prominent in the construction of the concrete locks as in any part of the canal work, and one method of saving time and labor has been to get all possible supplies from the Isthmus itself. Broken stone for the concrete was brought from a large quarry and crushing-plant at Porto Bello, eighteen miles east of Cristobal, the plant having a capacity of twenty-four hundred cubic yards in eight hours; sand was brought from old French Nombre de Dios beyond; and cement, unavailable near at hand, from the United States in two large steamers bought for the purpose, each of which carried forty-five thousand barrels. Nearly five million barrels were used in all. The rock, sand and cement were brought by boat and rail to the big concrete-mixing plant at Gatun. Here the cars containing the materials ran up an incline and emptied them into bins over the big revolving mixers. These mixers were so arranged as to be easily tipped down at one end and the materials, thoroughly mixed into concrete, run out into big buckets set on flat cars, standing close to the mixers. These buckets in turn were taken on the flat cars to the locks near by. Here on either side of the excavation were high, movable, steel towers on tracks; strung across the locks from one tower to another were steel cables with hooks suspended from them. By a manipulation of levers in the towers, these hooks could be lowered over the buckets of concrete, fastened by hand under the handles of the buckets, and then lifted, swung along to a spot directly over the place where the concrete was wanted, and lowered. Here the men poured out the concrete, and the buckets were again swung up and away and set on the empty cars that were waiting. Signals to men manipulating machines at a distance were given by waving flags. In building the foundation, each frame for receiving the cement was built at its own place, but in building the walls, big steel frames set on cars running on parallel tracks were used. When one section of the wall had been poured into a frame thus made, and had set, the frames were wheeled away on the cars to a place just adjoining the last completed section and another part poured. The finished locks are the longest concrete trough ever built, and practically one great monolith.

A PASSAGE THROUGH THE FINISHED CANAL

It has been said that the Canal is Panama's big bridge of water. Though this bridge has been in use now for several months, due to Col. Goethals' great efficiency in accomplishing the task set him, the Canal will not be opened formally until spring, 1915. Then the United States battleship Oregon will lead a fleet through the Canal on its way to the expositions on the western coast. At that time, in place of the long Cape Horn route, the Oregon will pass from the Caribbean waters to the Atlantic between two breakwaters into Limon Bay and come to rest in the sea-level entrance to the Gatun locks. Then through the west flight of locks, it will be lifted by three steps eighty-five feet to Gatun Lake. Through this beautiful lake, dotted with green islands, the tops of former hills that have been nearly

submerged, it will steam quickly along a course made up of straight lines and sharp angles, marked out by night by lighted buoys. Then through Culebra Cut, it will travel more slowly and at the further end will be lowered by a single lock at Pedro Miguel thirty feet to Miraflores Lake. It will travel across this small lake and through two locks at Miraflores, by which it will be lowered to the sea-level channel in Panama Bay, by which channel it will go out past the breakwater on the east, past Naos Island, and into the Pacific Ocean.

THE MILITARY VALUE OF THE CANAL AND ITS FORTIFICATIONS

From the time of the first work on the Canal, there arose the problem of whether it should be fortified or not. This problem could not be solved until the future uses of the Canal to the United States were thoroughly agreed upon and the necessary means of gaining these and at the same time maintaining the conditions imposed upon us by various nations were investigated by those in power. The attempt to settle these questions has caused much discussion. The business men felt that the Canal was built primarily to reduce the expense and risk of commerce, to make possible the expanse of industry, and to enlarge the profitable employment of labor. With this point of view there seemed to be no need of fortifications, and the argument even became that they would not only be a step toward militarism but contrary to our first agreement with Great Britain regarding the neutrality of the Canal.

The military man, on the other hand, maintained that the Canal was to be without doubt a commercial convenience for all nations, but it was being built primarily because it was a military necessity for the United States. South America, he argued, is not liable to become a formidable enemy soon; it is not likely that both an Asiatic and European country will attack our shores at the same time; no one nation is liable to have a fleet large enough to properly protect home waters and at the same time attack our coasts. These conditions mean that the United States should be able to force a hostile fleet, in moving from one coast of our country to the other, to travel around South America, a distance of eight thousand miles, consuming two or three months; while the home fleet in this time might use the Canal as a short cut, move easily to the other coast, and prepare its defense. Thus the present fleet could have its efficiency and value practically doubled. This saving on the fleet alone, he estimated, would pay for the Canal in the first decade. In much the same way, the value of our army, which, it is urged, is much too small for an adequate defense of the coastal approaches outside the reach of our fortifications, could be increased. This great disadvantage of going around Cape Horn in time of war can be forced upon the enemy only by our having such fortifications as will close the canal to them. But if this can be done and at the same time give the advantage of an open canal across the Isthmus to us, attack upon the United States will be very much discouraged; our old isolation, which has heretofore determined to a large extent our whole military

policy, will be maintained, and a fortified canal, instead of being a step toward militarism will become a step in the opposite direction.

In a way, the coast of the Canal Zone is the same as the coast of the United States, and as such needs defense. Furthermore, a canal, for whose construction the United States has paid nearly four hundred million dollars, should not be left so that in time of war it can be used by that country's disadvantage. Big coaling and oiling stations are being established on the Isthmus, for often a longer route is cheaper than a short one if the latter can offer no fuel en route. These stations must be protected. But what of violating our agreement with Great Britain?

The conditions of the Hay-Pauncefote treaty have already been stated. This treaty itself did not specifically give the United States the right to fortify the canal and when discussions regarding the advisability of doing so arose, Great Britain objected to any defense being built. She said it would violate the treaty and she called attention to Suez as an example of neutrality. The conditions at this canal are rather interesting and Great Britain's objections to fortifications at Panama in light of these conditions, amusing. The Suez Canal has always been a private enterprise, but many nations are interested in it, and perfect neutrality is guaranteed. Great Britain, however, holds the controlling shares, and still more holds all approaches to it at either end, with these approaches so well fortified that no enemy can get near enough to the canal to take advantage of that neutrality. By the Hay-Pauncefote treaty the United States guaranteed commercial neutrality to all nations wishing to use the canal, and to maintain this in time of war between two nations, fortifications seem necessary. Ten times in the last fifty-five years, it has been necessary for an armed force from the United States to intervene in order to keep the Panama Railroad neutral.

All conditions considered it seems wise for the United States to fortify the canal, and the correspondence on the subject between the British and American negotiators shows unmistakably that Great Britain finally conceded the right.

The kind and amount of fortifications necessary were determined by the dangers to which the canal itself seems liable and by the military uses to which our country may wish to put it. Since the great value of this passage to us in time of war depends upon the chance it gives us of concentrating our forces quickly on either coast, an enemy might naturally be expected early in the conflict to attempt to close the passage through the canal. The easiest way to do this would be by destroying the locks and dams, as the canal could be put out of working order temporarily by wrecking the gates of any pair of locks and quite lasting damage done by blowing up the spillway wall. These then must be protected from bombardment. Again, the enemy might plan that a land force or their fleets' marines landed some distance from the canal itself might attack and wreck the locks. Such a body would probably be small, however, and would have to risk much in the jungle. An army might be helped by Central or South American troops, though this again is not likely, until our fleet were de-

stroyed, as transportation of a large number of men by the enemy would need considerable guarding. On the whole, just a single man coming in by stealth could do as much damage by explosives as a larger number of men. These latter possibilities seem to demand some means of protecting the canal from the landside. An enemy would find the exit of our fleet from either end of the canal a strategic occasion for attacking it. Some means then must be devised for holding an enemy at a sufficient distance to allow our fleet to come through and spread out into line of battle before meeting the hostile fleet.

Now to safeguard against these dangers it was decided that the canal needed two kinds of defense, seacoast fortifications and land defenses by a mobile garrison. On the Atlantic side the fortifications were built on points of land on both sides of Limon Bay; on the Pacific side they were put on Naos Island, which is attached to the mainland by a breakwater. These fortifications are of guns and mortars in concrete emplacements. They are to prevent bombardment of the locks; to keep the enemy far enough away from the canal entrances so that the United States ships can come through and have a safe space in which to spread out into line of battle before meeting the hostile fleet; to keep the enemy from landing within six or seven miles of the entrance, the distance over which they will be effective; and also within the same radius, to assist the land force in defending itself against the approach of an enemy by land. Behind the forts at each entrance is a mine field. The forts are manned by twelve hundred men of coast artillery. The land force is made up of six or seven thousand men, mainly infantry, with a battalion of artillery and a small force of cavalry. This force is to protect the locks or any destructible part of the canal against an enemy that may have landed. Their methods will probably be those of jungle warfare. They will attempt to hold the enemy back in the jungle, force them to fight under strange conditions and camp in unhealthful surroundings. They themselves will have become thoroughly acclimated and will have been trained to fight under existing conditions. Permanent barracks are to be erected on the line of the Panama Railroad somewhere between Gatun and Miraflores to house the infantry and artillery. No private ownership is allowed throughout the Zone and practically no settlement. Jungle is to cover all trails and paths and produce a tangle through which passage can be obtained only by use of a hatchet.

FUTURE GOVERNMENT AND MAINTENANCE

During the years of construction, the Canal Zone was under a military form of government—that is, the work was under the department of war and Col. Goethals, an officer of the army, was in full control. The future government will be of a modified territorial form, the governor, appointed by the President of the United States with the approval of the senate, and local officers elected by the people of the territory. Col. Goethals urged (1) that men for operating the canal and participating in the government of the Zone be selected from the corps already trained there, from the men

whose lives and loyalty are bound up in it; (2) that the present high wages, once and a half that for similar work in the United States, be reduced to normal; and (3) that civil service be established so that men may feel secure in their positions and build up their homes there.

In keeping with these suggestions Col. Goethals is now at the head with the title of Governor of Panama Canal. He is also head of the Department of Operations and Maintenance. Commissioned officers from the United States army have been made Engineer of Maintenance, Superintendent of Transportation, and Electrical Engineer. Besides these there are two captains of terminal ports, a superintendent of shops and dry docks, chiefs of purchasing, supply, accounting and health departments, a superintendent of hospitals, a chief officer of quarantine and an executive secretary.

Col. Goethals estimated that the maintenance of the Canal and Zone should be about three million dollars a year, and this amount is to come from the tolls paid by vessels using the canal. There has been much discussion, of course, as to how much these tolls should be and at times a strained international relation has appeared on the horizon. In order that the canal shall serve the purpose for which it was planned, these tolls should be as low as possible so as to assure its use in every case where the route through it would be of advantage; on the other hand they should be large enough to cover the cost of maintenance.

Many have argued for a free canal for United States ships, but foreign nations, especially Great Britain, claimed this to be contrary to our treaty. The canal will be paid for by the taxes levied upon Americans; are they to pay for the canal and also for the privilege of using it? European nations either pay the tolls of their steamships through the Suez Canal or pay the equivalent or more to the companies operating the ships. They will doubtless do the same for ships using the Panama Canal. The United States does not pay subsidies. Shall her shippers be the only ones to get no help toward paying tolls through their own canal?

The first decision of our government in regard to tolls was that all our ocean liners should pay tolls equal to those of other nations, but that our coastwise vessels should be exempted. This seems entirely in accordance with our treaty since nothing but American owned ships may engage in coastwise trade here. It did not seem to be a decision that could in any way influence other nations. Great Britain and other nations objected, however, and demanded that we repeal the law. After much discussion by the press and by members of Congress, the latter yielded to Commissioner Johnson's advice that the maintenance of the canal needed the tolls of the coastwise vessels and to President Wilson's appeal that we stand by the decision of the nations in general, and the same tolls are now imposed upon both vessels engaged in foreign and coastwise trade.

As they now stand, the tolls for merchant vessels carrying passengers are \$1.20 per net vessel ton or each one hundred cubic feet; on vessels in ballast without passengers or cargo, forty per cent less than this; for naval vessels other than transports, colliers, hospital ships and supply ships, which are subject to the same toll as merchant vessels, \$.50 per dis-

placement ton. Now freight vessels can transport two or three tons of cargo for each net vessel ton, and in actual service they average about two freight tons per vessel ton. This puts the tolls at about \$.60 per ton of freight as compared with the \$3.00 and \$3.50 charged by the railroads per freight ton, the new toll being one-fifth the old.

FUTURE VALUE OF CANAL

By the influence of the canal, every nation with ships on the sea, or furnishing cargo for the ships of other nations, will receive new life. With the shortening of distances between producer and consumer, and between the producer and regions that have so far been too remote to be consumers, the output in raw and manufactured products will be increased for all these nations. It is, however, the nations of the western hemisphere that are to receive the greatest stimulus and of these especially North America. Next to the United States, the countries most benefited will be those of South America through the stimulus to their trade and industries. Panama has already received great help. She has had her social conditions completely revolutionized and much for the better. She now has a chance to develop her natural resources, the soil, the metals, coal and oil; and tourists, flocking to that narrow strip of land to see the wonders wrought by the United States, will bring in considerable wealth. It is not unlikely also, that the Isthmus may develop as a resort for winter homes.

TRADE AND INDUSTRY

The value of the canal to the United States in a military way has already been suggested, but as great as this value may seem to the military men, the general public probably agrees with the business man that it is for peaceful purposes rather than for military uses that the canal has been built; that the primary object has been to promote our domestic trade, and to remove the handicap under which we now compete with the people of Europe for the vast commerce of the Pacific. Trade is undoubtedly to be stimulated by this new route and, through trade, the industries that supply the markets. The cotton, iron and coal of the southern United States will now be wanted on the western coast of the United States and of South America, and the industries in those states will be stimulated because of this demand. The coarse cotton goods of the same region are such as to satisfy the demands in Central and South America, Asia, Hawaii, and the Philippines, and their manufacture will be increased because of the ease with which they can be transported to their markets. Panama is to be one of the largest coaling stations in the world, and though the Isthmus has something of a supply, coal-mining is sure to be carried on to a greater extent than formerly throughout all the coal states of the United States, especially in West Virginia, Tennessee, and Alabama. The effect of the Canal on ship-building has been in evidence some time.

Both American and European shipyards have been reporting large orders since the spring of 1913—not all due to the canal, but a large enough proportion has been designated as especially for use through the canal to show

its effects in this business. The American-Hawaiian Steamship Company put in an order in the summer of 1913 at a Philadelphia shipyard for eight freighters, six with refrigerator space, to carry Hawaiian pineapples and California citrus fruit. This is the largest single order ever given for American merchant ships to an American yard. This company will then be operating a fleet of twenty-six ships. Its trade has, until the trouble in Mexico, used the Tehuantepec and Panama Railroads; since then it has been obliged to use the Cape Horn route, but it will as soon as possible use the canal. Its order of 1913 shows what one company has done for the shipbuilding industry and many other orders, only slightly smaller, have been given to other American and many foreign shipyards.

A recent summary of the Tehuantepec-Panama Trans-Isthmian Railroad traffic shows a rapid recent increase and it is predicted that practically all of this traffic will be absorbed by the canal. It is agreed in shipping circles that "the Panama Canal has already been responsible for the addition of more sea-going steam cargo tonnage to the American merchant marine than any other single factor in our history."

The trade that has gone across the Tehuantepec and Panama railroads has paid for crossing the Isthmus three dollars and a half and three dollars respectively per cargo ton. In the case of the American-Hawaiian Steamship Company this has meant one-third of the through rate. The charge has been paid for taking the cargo from the ship on one side, carrying it across, and loading it on a ship on the opposite side. Often there has been so much traffic that great congestion has arisen with consequent delay. For this class of trade—that already using the Isthmus—the canal will (1) overcome the delay due to the unloading and loading and to the congestion; and (2) it will prevent the damage due to the handling and congestion. For the trade that has hitherto used the Cape Horn route, it will give a shorter route and therefore a quicker delivery, and supposedly less freight charges. The distances will be shortened from

New York to Yokohama by 3,750 miles

New York to Shanghai by 2,000 miles

New York to Australia by 3,000 miles

New York to Western South America by 3,500 to 7,000 miles.

Europe to Western South America by 3,000 miles

Europe to Western North America by 5,000 miles

It is further expected that there may be an entirely new trade established in those bulky materials that cannot afford either the handling across the Isthmus or the long trip around the Horn.

The reduction in tolls on traffic and the shorter route from one ocean to the other, which means a reduction in cost of carriage, make one think that trans-continental freight rates should be cheaper. There is chance, however, that they may not be. Service is not the only factor in rates. Rival companies are in the habit of settling rates by conference and charging whatever the traffic will bear, and there is liable to be a great enough demand for the railroad route, so that companies need not make many concessions to their patrons. Only the large producer, who can use his own

ships or charter them, is likely to be able to force rates very much. The railroad and coastwise ship companies will be rivals, and there will be a tendency to reduce railroad rates. The railroads, however, will probably lost at least one-tenth of their traffic, maybe more, and with that reduction in traffic they may feel they have already lost enough without reducing rates. E. R. Johnson, United States Special Commissioner on Traffic and Tolls, says that probably competition will do little to reduce rates; that probably the pressure of public opinion, exerted by business men and newspapers, and embodied in laws against trusts and monopolies, will influence the makers of rates more than competition.

TOURIST TRAFFIC

The big increase in ocean traffic will not be entirely confined to freight; the tourist traffic is going to be regenerated. New companies were early organized in Europe, and many ships ordered by old companies just for tourists from Europe to the Pacific coast of the United States. Several new routes are already planned. One is from Liverpool to Portugal, Spain, Brazil, Argentina, through Magellan Strait, along the western coast of South America, through the Panama Canal to Havana, Cuba, and back to Europe. This route is to circle South America both ways. A line is to be established between the Mediterranean and Pacific coast of North America for immigrants to our western states. A Japanese company has planned a route to New York; a Chilean steamship company has organized service from Chile to New York. European companies are advertising world tours by way of the canal. Canadian railroad lines, that are not affected by the United States laws forbidding their engagement in coastwise trade, are planning ships to ply around our coast.

Though these changes will not come all at once this great readjustment of ocean traffic routes of the commercial world will probably affect half the countries of the globe. And as one sees the far-reaching effect of the wonderful task so nearly completed by the United States, he cannot but feel that the words on the seal of the Canal Zone were well chosen, "The land divided, the world united."

REFERENCES

- Official Handbook of Panama Canal.
- The Isthmian Canal. H. H. Rousseau.
- Some Problems of the Panama Canal. H. L. Stimson.
- Treaties and Acts of Congress Relating to the Isthmian Canal.
- Manual of Information Concerning Employment for Service on the Isthmus of Panama. Isthmian Canal Commission.
- Panama and the Canal. Alfred Hall and Clarence Chester.
- The Panama Canal. Lieut.-Col. Geo. W. Goethals, U. S. Army. National Geographic Magazine, April, 1909.
- Construction of Concrete Locks of the Panama Canal. H. Prime Keifer, Scientific American, July 17, 1909.

Construction of the Canal. Annabel Lee. Outlook, Sept. 24, 1904.

A Little History of the Panama Canal. Outlook, April 24, 1909.

Panama Canal Tolls. Outlook, Feb. 24, 1912.

In Justice to Colombia. Earl Harding. World's Work, Oct., 1913.

Panama Canal for Foreign Ships. Agnes C. Laut. Technical World Magazine, May, 1913.

Defense of the Panama Canal. Henry L. Stimson, Scribner's Magazine, July 1913.

Panama's Bridge of Water. J. B. Bishop, Scribner's Magazine, July 1913.

What the Canal will Accomplish. E. R. Johnson. Scribner's Magazine, July 1913.

Panama Canal. John W. Herbert. Bulletin of American Geographic Society, April, 1913.

Short Articles in Literary Digest and Outlook during 1914.

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